(12) UK Patent Application (19) GB (11) 2 174 945 A

(43) Application published 19 Nov 1986

(21) Application No 8605925

(22) Date of filing 11 Mar 1986

(30) Priority data

(31) 8506255 (32) 11 Mar 1985 (33) GB

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(51) INT CL[4]
B23H 3/00 // 9/14

(52) Domestic classification (Edition H):
B3V 102 EQ
U1S 1573 1754 1884 2316 B3V

(56) Documents cited
GB 1338221 US 3909388
GB 1012587

(58) Field of search
B3V
Selected US specifications from IPC sub-classes B23H B23P

(54) Electrochemical machining of subsea pipe

(57) There is provided a method of forming a hole in a subsea pipe (13) in which a hollow cylindrical tool electrode (10) having an open end (11) lying in a plane normal to its axis (12) is disposed so that said end is adjacent to the pipe wall and said axis is transverse to the pipe. The tool electrode (10) is rotated on said axis (12), an electric voltage is applied between the tool electrode and the pipe to cause electrochemical machining of the pipe wall, and the tool electrode is moved along said axis (12) to maintain a predetermined gap between the nearest parts of electrode and the pipe wall as machining proceeds. The electrode has an outside diameter which is a significant proportion of the pipe's diameter. Preferably, the electrode has an outside diameter at least equal to one-half of the inside diameter of the pipe. The operative face end of the tool electrode (10) is coated with non-conductive particles to maintain the necessary electrical gap between it and the pipe.

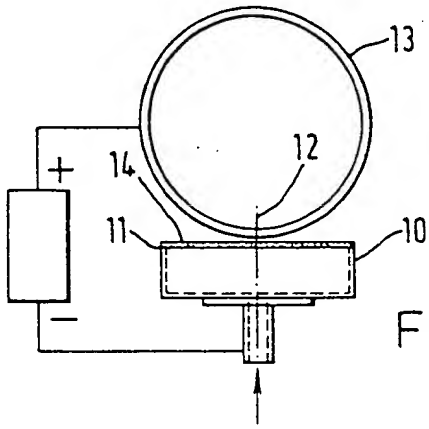

FIG. 2.

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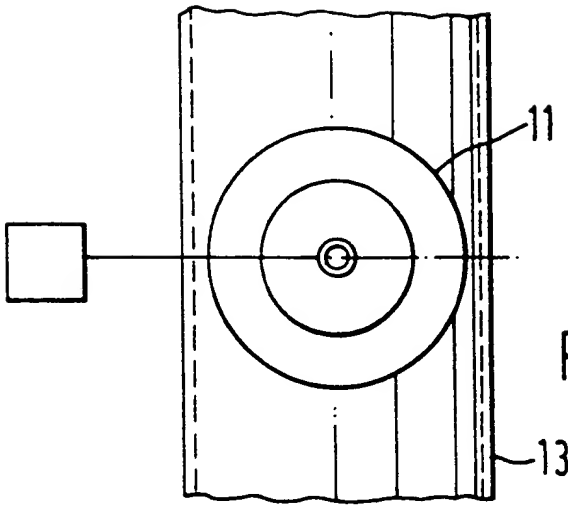

FIG. 1.

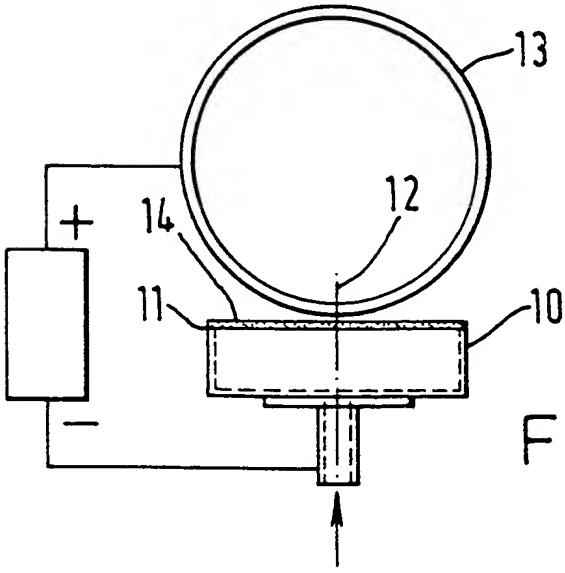

FIG. 2.

SPECIFICATION

Electrochemical machining

This invention relates to electrochemical machining.

In electrochemical machining, a DC electric current is passed between a tool electrode and a workpiece which are separated by a liquid electrolyte so that material is removed from the workpiece. Many proposals for electrochemical machining have been made. In U.K. Patent Specification No. 1338221, it is indicated that a rotating tubular electrode may be used to drill holes in metal submerged in sea-water, such as a ship's hull or a pipe line. The sea-water constitutes the electrolyte. U.K. Patent Specification No. 2096518A indicates that a method involving a combination of electrochemical machining and electro discharge (spark) machining was expected to be useful for undersea cutting purposes and refers to such applications as hole drilling and trepanning. As made clear in the prior art proposals, the size of the gap between the tool electrode and the workpiece is critical to the success of the machining process. In U.K. Patent Specification No. 1338221, the rotating tubular tool electrode is illustrated as being used with a substantially flat workpiece, so that there is a gap of constant size around the whole of the end of the tool between the tool and the workpiece. The holes contemplated in the prior art proposals have therefore been of small diameter compared with the radius of curvature (if any) of the workpiece.

Subsea pipes such as are used in the oil and gas industries are of large diameter (e.g. 24") and substantial thickness (e.g. up to 4"). Frequently, it is necessary to cut a large hole in a pipe. For this purpose, mechanical and thermal cutting equipment has been used. The use of such equipment in a subsea environment is difficult and costly.

The present invention is based on the surprising discovery that it is possible to form large holes of good standard in subsea pipes by electrochemical machining.

According to the present invention, there is provided a method of forming a hole in a subsea pipe in which a hollow cylindrical tool electrode having an open end lying in a plane normal to the cylindrical axis is disposed so that said end is adjacent to the pipe wall and said axis is transverse to the pipe, the tool electrode is rotated on said axis, an electric voltage is applied between the tool electrodes and the pipe to cause electrochemical machining of the pipe wall, and the tool electrode is moved along said axis to maintain a predetermined gap between the nearest parts of electrode and the pipe wall as machining proceeds, the electrode having an outside diameter such that material is removed from the pipe at different positions which are increasingly spaced apart from one another circumferentially of the pipe during the course of electrode movement.

For most purposes, the electrode will have an outside diameter at least equal to one-half of the inside diameter of the pipe. If desired, it may have an outside diameter substantially equal to the inside diameter of the pipe.

To maintain the aforesaid predetermined gap, the end of the tool electrode may be coated with non-conductive particles, e.g. diamond or borazon, which engage the pipe, while the electrode is continuously urged towards the pipe wall, e.g. by a compression spring.

Sea water may be pumped into the interior of the tool electrode at an adjustable rate so that it emerges through the gap between the electrode and the pipe.

The invention also provides apparatus for carrying out the method set out above.

The following is a description, by way of example only, of an embodiment of the invention, reference being made to the accompanying schematic drawings, in which

Figures 1 and *2* illustrate respectively plan and side views of apparatus forming a circular hole with a rotating electrode.

Figures 1 and 2 show a rotating circular cutter 10 in the form of an axially movable steel cylinder having an open end 11 lying in a plane normal to a radial line 12 from a steel pipe 13 to be cut. Electrical stand off is provided by borazon or diamond-coated particles 14 embedded on the cutting face, i.e. the open end of the electrode, to maintain a gap (suitably of 0.003" to 0.005") across which electrolysis occurs when a direct electric current flows between the cutter and the pipe. Fresh sea-water is pumped into the cutter and out through the gap (e.g. at 80 litres/minute) by maintaining a positive pressure so as to wash away the products of electrolysis and keep fresh electrolyte in the gap. As shown, the pipe is of 24" outside diameter and 1" wall thickness and the cutter is of 20" diameter. Different dimenions may of course be used. Contact pressure between the cutter and the pipe is maintained by a linear compression spring. It will be seen that as the cutter is advanced towards the axis of the pipe, initially metal is removed from two positions spaced apart along the pipe by a distance equal to the diameter of the cutter. As soon as the cutter penetrates inside of the pipe, metal is removed from four different positions spaced apart lengthwise and circumferentially of the pipe. The circumferential spacing on the pipe of the cutting positions gradually increases as cutting proceeds and the lengthwise spacing decreases until metal is removed only from two circumferentially spaced positions near the end of the cutting operation.

The electric current is DC and may be varied from 0 - 600 amps. Higher currents, e.g. up to 800 amps may be used. The electrolyte flow may for example be varied from 0 - 300 litres per minute. The pipes shown in the drawings have an outside diameter of 24" and a wall thickness of 1", but holes may be cut in pipes having other dimensions, e.g. with a wall thickness of up to 4".

CLAIMS

1. A method of forming a hole in a subsea pipe in which a hollow cylindrical tool electrode having an open end lying in a plane normal to the cylindrical axis is disposed so that said end is adjacent to the pipe wall and said axis is transverse to the pipe, the tool electrode is rotated on said axis, an electric voltage is applied between the tool electrode and the

pipe to cause electrochemical machining of the pipe wall, and the tool electrode is moved along said axis to maintain a predetermined gap between the nearest parts of electrode and the pipe wall as machining proceeds, the electrode having an outside diameter such that material is removed from the pipe at different positions which are increasingly spaced apart from one another circumferentially of the pipe during the course of electrode movement.

2. A method according to claim 1 wherein the electrode has an outside diameter at least equal to one-half of the inside diameter of the pipe.

3. A method according to claim 1 or claim 2 wherein the electrode has an outside diameter substantially equal to the inside diameter of the pipe.

4. A method according to any preceding claim wherein the end of the electrode is coated with non-conductive particles and the electrode is continuously urged towards the pipe wall.

5. A method of forming a hole in a subsea pipe substantially as hereinbefore described with reference to the accompanying drawings.

6. Apparatus for forming a hole in a subsea pipe substantially as hereinbefore described with reference to the accompanying drawings.

Printed in the UK for HMSO, D8818935, 9/86, 7102.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.